Relationship between medicine ball explosive power tests, throwing ball velocity and jump performance in team handball players

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Annotation:
In this study, the relationships between medicine ball explosive power tests, jump and handball throwing velocity performance in team handball players were investigated. Explosive test was measured by a medicine ball throw. Specific explosive strength was evaluated by making 3 types of overarm throw: standing position, using an adapted power tests (without run-up), a 3-step running throw (T3-Steps) and a jump shot (J3). The jump test (SJ, CMJ and FCMJ) were determined using the OptoJump. The medicine ball explosive power test was closely related to T3-Steps. Significant relationships were observed between medicine ball explosive power tests and (J3) and (T3). The Medicine ball explosive power test is also positively related to vertical jump ability represented by Squat Jump (SJ) and Countermovement Jump (CMJ). The results suggest an association of the medicine ball explosive power tests to performance in throwing events.

Keywords: throwing, jumping, test, handball.

Introduction.
Overhead throwing in individual and team sports is a complex body activity with sequential activation of body parts through the link system which, in a right-handed thrower, goes from the left foot to the right hand. Toyoshima and al. (26) have shown that 53.1% of the velocity of the overhand throw could be attributed to arm action, while the remaining 46.9% was due to the step and body rotation. From the acceleration phase of throwing, the arm is whipped from the position of extreme external rotation to one of internal rotation. Tullos and Erwin (27) have stated that an increased rotational range of motion in baseball. It was found that, the pitcher is required to generate a large amount of torque in internal rotation to project the ball with sufficient velocity to be successful.

In team handball, the ability to score a goal depends, in large part, upon the velocity of the ball and the accuracy of the throw. Thus, the exploration of the relationship between explosive test of throw and ball velocity is of paramount importance, since the existence of such a relationship, which is highly advantageous in sports involving throwing movements. The ball velocity and its relationship with isokinetic strength has been the subject of many studies directed mainly toward athletes and more specifically to baseball pitchers (4, 27). Pedegana and al. (24) tested isokinetically eight professional base

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164

Педагогіка, психологія та медико-біологічні
ently, the relationship between ball velocity and medicine ball explosive power tests has not been studied thoroughly in team handball.

**The aim and methodology of the research.**

The aim of our study was to examine the relationship between the medicine ball explosive power tests to jumping ability in team handball players with various throwing abilities, in three types of shot (on the spot, with a crossover step and with a vertical jump).

Nineteen male handball players (n=19) volunteered for the investigation (age: 21.37 ± 1.92 years; mass: 77.7 ± 9.67 kg; height: 1.83 ± 0.06 m and body mass index: 27.32 ± 5.85 kg.m²). Explosive test was measured by a medicine ball throw. Specific explosive strength was evaluated by making 3 types of over arm throw on an indoor handball court: standing position, using an adapted chair (without run-up TW), a 3-step running throw (T3-Steps) and a jump shot (J3). The characteristics (jump height) of the Squat Jump (SJ), the Countermovement Jump (CMJ) and the Free Countermovement Jump (FCMJ) were determined using the OptoJump measurement technology (Microgate, Bolzano, Italy).

**Testing Procedures**

On the first day of testing, the protocol was explained to the subjects, and they then watched a demonstration of the medicine ball throw. This was followed by a practice session. Subjects were given as many practice throws as they desired until they were able to make 3 consecutive throws to within 0.50 m of their longest practice throw. Testing consisted of starting with the feet shoulder width apart, heels on the zero measurement line, and the medicine ball held with arms straight out front at shoulder height. The countermovement consisted of the subjects flexing the hips and knees. At the same time, they also flexed forward at the trunk, lowering the medicine ball to just below waist or hip height. After the countermovement, the subjects began to thrust the hips forward and to extend the knees and trunk. They flexed the shoulders, elevating the ball back up to shoulder height and beyond as they threw it back over their head. The arms were maintained in an extended manner. The finishing point was with the ankles plantar flexed; the knees, hips, and trunk extended; and the shoulders flexed to above the head. During the countermovement, the subjects were asked not to bend the knees or hips any more than they normally would for a standard countermovement vertical jump. The shoulders maintained at least 45° of shoulder flexion in relation to the trunk. At the end of the throw, the subjects’ feet were allowed to leave the ground, as would happen with a jumping motion, to minimize any deceleration component of the vertical ground reaction forces (Figure 1). The subjects were also asked to keep their arms as straight as possible as they threw the ball back over their head with a pendulum action. This instruction was meant to force the legs, trunk, and shoulders to generate the power, as would be the case in a vertical jump (3).

**Handball throwing**

The throwing test using an adapted chair was evaluated on an indoor handball court. One type of throw without run-up, (Tn) was performed with one hand from a standing position, using an adapted chair. The trunk of the player was immobilized by a belt blocked; the shoulder was maintained in 90 degree of abduction and external rotation, and the elbow was flexed to 90 degrees. The test was undertaken after a 15-minute standardized warm up and using a standard handball (mass 480 g, circumference 0.58 m). To simulate a typical handball action, the players...
Our main purpose was to examine relationships between medicine ball explosive power tests and throwing ball velocity at different jump shot. The hypothesis that both upper and lower limbs contributed to throwing performance, was confirmed. T_3-Step was closely related to medicine ball test \((r = 0.69, p<0.01\) for both relationships) and it also showed moderately strong relationships to jumping ability \((r = 0.56, p<0.05; r = 0.62, p<0.05\) respectively). This seems the first investigation to demonstrate the substantial contribution of the lower limb muscles to the throwing velocity of handball players.

The main finding in our study was that, generally in handball, in three types of throw with various throwing abilities, and jumping performance was related to ball velocity. When comparing our findings with the results of Fleck’s and al. (11) study conducted in handball players of the U.S. National Team, we observe both agreements and disagreements. Fleck et al. (11) did not find a significant relationship between the ball velocity in set shot and shoulder rotation at any of the isokinetic speeds studied \((180, 240, 300\ deg/sec)\), which is in agreement with our results regarding the shot on the spot \(\text{same as set shot}\). However, they found a significant correlation between concentric rotation and jump shot at all speed tested.

Hawley and al (14) found a correlation coefficient of 0.63 between the peak power of the upper limbs as evaluated by the Wingate test and the speed of a 50-m swimming sprint. In their study, the ratio of upper limb peak power to lower limb peak power was 45%. These results seem in accordance with our present study; we found a correlation of 0.69 between explosive medicine ball test and \(T_{3\text{-Step}}\) (Table 3, Figure 1).

Several recent studies of elite male handball players \((8, 12, 13, 18)\) investigated the relationships of throwing velocity to bar velocity and bar power during bench press or half squat. Gorostiaga EM et al. (12) reported a close relationship between 3-step running velocity and the bar velocity at 30% of 1-RM\(_{\text{up}}\) \((r = 0.72, p<0.01)\), with a moderate relationship to power at 100% of body mass in the half squat exercise \((r = 0.62, p<0.05)\). A close relationship between standing throwing velocity and 1-RM\(_{\text{up}}\) \((r = 0.80, p<0.001)\) was also reported \((8, 9)\).

Moreover, throwing velocities showed moderate relationships with the bench press bar velocity and the power achieved at 38%, 52% and 52%, 67% of body mass respectively \((18)\). Nevertheless, it is difficult to compare these results with our findings, because of differences in methodology and the type of ergometer that was used. The studies cited used a rotary encoder linked to the end of the bar to record bar displacement, average velocity and average power of the bar. Moreover all of these parameters were only assessed during a concentric bench press exercise. In our investigation, we measured explosive power as dependent variables. In addition, we adopted a simultaneous eccentric-concentric upper limb muscle contraction with medicine ball throw.

To our knowledge, the relationships of medicine ball explosive power tests, throwing ball velocity as measured with a simultaneous eccentric-concentric contraction have
Table 1

Results of all parameters measurements (n = 19).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine ball explosive power tests (m)</td>
<td>15.35 ± 2.34</td>
</tr>
<tr>
<td>Ball-throwing velocities (m s⁻¹)</td>
<td></td>
</tr>
<tr>
<td>Throwing test using an adapted chair (Tₜ)</td>
<td>20.97 ± 4.59</td>
</tr>
<tr>
<td>3-Step running throw (T₃₃₈₈₈₈₈)</td>
<td>32.43 ± 8.30</td>
</tr>
<tr>
<td>Jumping shot (JS)</td>
<td>35.18 ± 11.22</td>
</tr>
<tr>
<td>Squat Jump (SJ)</td>
<td>35 ± 5.38</td>
</tr>
<tr>
<td>Counter Movement Jump (CMJ)</td>
<td>45.60 ± 4.58</td>
</tr>
<tr>
<td>Free Counter Movement Jump (FCMJ)</td>
<td>43.22 ± 6.62</td>
</tr>
</tbody>
</table>

Table 2

Intraclass correlation coefficients showing the reliability of various measures of ball-throwing velocities, and jump tests

<table>
<thead>
<tr>
<th>Parameter</th>
<th>ICC</th>
<th>90% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball-throwing velocities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Throwing test using an adapted chair (Tₜ)</td>
<td>0.96</td>
<td>0.91 to 0.97</td>
</tr>
<tr>
<td>3-Step running throw (T₃₃₈₈₈₈₈)</td>
<td>0.97</td>
<td>0.92 to 0.98</td>
</tr>
<tr>
<td>Jumping shot (JS)</td>
<td>0.94</td>
<td>0.95 to 0.98</td>
</tr>
<tr>
<td>Squat Jump (SJ)</td>
<td>0.95</td>
<td>0.93 to 0.98</td>
</tr>
<tr>
<td>Counter Movement Jump (CMJ)</td>
<td>0.93</td>
<td>0.91 to 0.96</td>
</tr>
<tr>
<td>Free Counter Movement Jump (FCMJ)</td>
<td>0.97</td>
<td>0.93 to 0.98</td>
</tr>
</tbody>
</table>

Table 3

Correlation between medicine ball explosive power tests to jumping ability in team handball players with various throwing abilities

<table>
<thead>
<tr>
<th>Medicine ball explosive power tests</th>
<th>Tₜ</th>
<th>T₃₃₈₈₈₈₈</th>
<th>JS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SJ</td>
<td>R = 0.61, p &lt; 0.01</td>
<td>R = 0.68, p &lt; 0.01</td>
<td>R = 0.50, p &lt; 0.05</td>
</tr>
<tr>
<td>CMJ</td>
<td>R = 0.60, p &lt; 0.01</td>
<td>R = 0.48, p &lt; 0.05</td>
<td>R = 0.17, no sig</td>
</tr>
</tbody>
</table>

not been described previously. Moreover, the medicine ball test, although rarely measured in handball studies, is rather specific to the action of handball throwing. Our results suggest that the simple measurements of explosive ball throw and jump performance could be useful tools for the handball coach, since these two exercises are often used in resistance strength training programs. Regular use of bench press and pull-over exercises could form an important component of a resistance training program designed to increase the throwing velocity of handball players. This suggestion merits the testing by further prospective research. This observation challenges the conclusion of Fleck et al. (11) that the ball velocity of a team handball jump shot depends more on upper extremity torque capabilities than doe’s ball velocity of a team handball set shot, even though the two tasks are similar.

A possible explanation for finding a significant relationship between shoulder rotators isokinetic strength and ball velocity only in jump shot and not during the shots with ground support (set shot in both Fleck’s et al. and the present study; cross over step in the present study) (11) is the following: During the set shot and the shot with a cross-over step, the feet are in contact with the floor, making it possible for the lower-extremity strength and trunk...
rotation to increase ball velocity by using the ground reaction forces. During the throwing motion of a jump shot, on the other hand, the player is in the air, making it difficult to use lower-extremity strength and trunk rotation to increase ball velocity during the throw.

In the study of Fleck’s et al. (11) the throwing motion in handball was examined with high-speed, two-plane, synchronized camera. It was observed that set shot throwing in handball is quite similar to baseball pitching and same differences in the throwing movement between the two sports are due to ball size and weight. This observation allows us to compare our results from team handball with those obtained in baseball.

The lack of a relationship between the strength of shoulder rotators and the ball velocity implies that the internal and external rotation is not the sole determinant factor in throwing movement in handball. Since throwing is a multipoint action, a variety of factors may contribute to this movement. Indeed, Atwater (1) and Toyoshima et al. (26) have shown throwing to be a complex motion involving all body parts. It has been suggested by Toyoshima that approximately 50 percent of throwing velocity is the result of body rotation, while the remainder is the result of upper-extremity action. Further, Pappas et al. (23) have described the anatomical sequence of throwing as proceeding from the fixed foot, up through the pelvis and
Figure 2: Relationship between 3-step running handball throwing, jump shot and medicine ball explosive power test.

\[ y = 2.2933x \quad R^2 = -0.24 \]

Figure 3: Relationship Counter movement jump, squat jump and medicine ball explosive power test.

\[ y = 2.4417x \quad R^2 = -0.36 \]
\[ y = 1.3622x \quad R^2 = -0.3582 \]
trunk, to the upper extremity. Sequential rotation of each body segment generates torque which applies force to the ball. Therefore, the importance of the lower extremity movement and trunk rotation should not be minimized when examining throwing movements.

**Summary and conclusions.**

Several conclusions can be drawn from this investigation regarding team handball players: Peak torque of upper limb shoulder rotators, generally is related to ball velocity. The lack of relationship between ball velocity and peak torque of internal and external shoulder rotators is more marked and consistent in shots with ground support (on the spot, with a cross-over step). In jump shots, the isokinetic strength of upper extremities seems to be, to some extent, related to ball velocity, but this relationship in not very clear and needs further investigation. Ball velocity is different among players with various throwing abilities in the three basic types of throw in handball (on the spot, with a cross-over step, with a vertical jump). Our results also highlight the contribution of both the lower and the upper limbs to handball throwing velocity, suggesting the need for coaches to include upper and lower limb strength and power programs when improving the throwing velocity of handball players.

**References:**


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